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*By Roland C. Clement**

INTRODUCTION

A recent article in ENVIRONMENTAL AFFAIRS[1] purports to "evaluate the evidence" in what is alleged to be "an intensive campaign to ban the insecticide DDT from use in, manufacture in, and export from the United States" in the past two years (i.e., since 1969).

Its author, Thomas H. Jukes, is a biochemist and presently a professor of medical physics at the University of California, Berkeley. He also has been the most vocal defender of the use of DDT. But to be helpful, any assessment of the anti-anti-DDT reaction articulated by Jukes should include comparison of the very similar pronouncements of Robert H. White-Stevens, a former colleague of Jukes at American Cyanamid Company and now professor in the Bureau of Conservation and Environmental Science at Rutgers University; Norman E. Borlaug, 1970 Nobel Peace Prize winner for his contributions to the production of high-yield wheat in Mexico; J. Gordon Edwards, entomologist at San Jose State College; and Donald A. Spencer, a wildlife biologist formerly with the U. S. Department of the Interior, but more recently with the U. S. Department of Agriculture (USDA) and the National Agricultural Chemicals Association (NACA), an industry trade group.

As an unecological rationalization of the food production needs of the rest of the world, the defense of DDT in this country is understandable, and could be dealt with on its merits. But most of the defenders of DDT mentioned above have recently engaged in intemperate attacks on the National Audubon Society and the Environmental Defense Fund, the two private conservation groups who have been the principal challengers of the continuing use of DDT in this country.

Jukes wrote that "The National Audubon Society, which appears

to have a predominantly white and middle-class membership, is one of the most active anti-DDT organizations. For a member to condone the use of pesticides would be tantamount to the deepest heresy in a religious sect. For an official of the Society to approve such use would be fiscal lunacy, in view of the tremendous amount of free publicity that the Society has received as a result of SILENT SPRING and other publications which have established a new mythology—the extermination of wild birds by agricultural pesticides. The Society shows underlying resentment of human beings and all their works, including cities, farms, highways, and especially private industry. Membership in the Society is a form of expiation of the sin of being one of the human race, the species that consumes "the environment." The Society stated recently that one of its two main purposes is 'the education of man regarding his relationship with and his place within the natural environment as an ecological system.' This pious pronouncement is actually intended to exclude man as an inhabitant of the Earth, except in small numbers and in a primitive, mythical, aboriginal state. The Audubon Society has no program for the relief of suffering among millions of human beings in the tropics." This, I suggest, is unreasonable and even malicious.

Robert H. White-Stevens has been, since 1963, the most avid anti-Rachel Carson lecturer and pamphleteer in this country. He quickly embraced, embellished, and gave widespread publicity to the Philip H. Marvin[2] thesis that the National Audubon Society's own data (especially the Christmas Bird Counts held annually since 1900 and published in what is now AMERICAN BIRDS) "prove" that birds have increased in numbers despite the use of DDT and other pesticides.

White-Stevens[3] poses the rhetorical question, "What does a critical examination of these bird data over the past twenty years reveal, particularly in the light of the introduction of synthetic pesticides in the early forties?" His answer is that "First, by the most conservative estimate the overall count reveals a bird population increase of at least 700%, which more than matches that of the human population." Why that last comparison is significant we are not told. "Second, with the exception of swans, ducks, doves, partridges, and pheasants, birds that are vigorously hunted, all other birds are either holding their own comfortably or are increasing at a prodigious rate. Thus robins, over which Miss Carson despairingly cries requiem as they approach extinction, show an

increase of nearly 1200% over the past two decades." Finally, White-Stevens, the fighter of myths, creates one of his own when he opines that "So many bird species have increased their numbers so substantially and have extended their living space so far that one is tempted to pursue Miss Carson's logic and make out a case for pesticides as being the major cause of bird survival through the reduction of insect-vectored avian disease."

Unfortunately, hundreds of agricultural experiment station newsletters and newspaper columns—the latter augmented by more hundreds of garden columns in newspapers and magazines—repeated this hoax of bird population increases and told the public that "the Audubon Society itself said (or admitted) birds are increasing," and that DDT and its relatives were at least in part responsible for these increases.

It has been impossible to rebut this inundation of distorted claims in the popular press in the last decade. Marvin[4] eventually published his thesis in a proper scientific journal; and E. E. Kenaga[5] promptly showed the entomological community that Marvin's ornithology was inadequate, and that crude summations of Audubon Christmas Bird Count data was not evidence upon which Marvin, White-Stevens, and Jukes could base a defense of DDT. It is noteworthy that all of the DDT apologists have been chary of normal scientific channels for the publication of their purported proof of the safety of DDT and its need in world agriculture. Instead they have assiduously burdened the popular press and other media with their alarums. Jukes published in AMERICAN SCIENTIST[6] but was quickly rebutted in the same publication by F. E. Egler.[7] Nor do any of them seem willing to benefit from the warnings of ornithologists[8] about incompetent use of ornithological data.

Norman E. Borlaug is the most recent, and because he is a Nobel laureate, the most newsworthy recruit to the anti-anti-DDT camp. It should be noted that his 1970 Nobel Prize was for contributions to world peace—via food production—and not for contributions to science. Following Borlaug's appearance at the Environmental Protection Agency's (EPA) 1972 hearings on the cancellation of DDT, a press conference arranged for him by Montrose Chemical Company, the principal manufacturer of DDT in this country, received much wider public attention than any of the scientific testimony presented during the six months of those hearings.

Borlaug's principal brief[9] is a 1971 McDougall Memorial Lecture delivered at the United Nations Food and Agriculture Organization (FAO) conference in Rome on November 8, 1971. The first half of this long talk was a paean to modern agriculture and the dilemma of human overpopulation. It made the usual emotional errors of agriculture's boosters in claiming, against all recent scientific evidence, (1) that primitive man was forced "to expend virtually all his energies in struggling to feed himself;" (2) that in modern nations such as the U.S.A. "only 5% of the labor force is engaged in farming and ranching;" and (3) that governments "must assure a reasonable return to the farmer and rancher, if they are not to drive the smaller operators off the farms and into the slums of the large cities.

The second half of the FAO lecture is a diatribe against environmentalists, especially the National Audubon Society and the Environmental Defense Fund, along with a lengthy agenda of proposed tasks to divert these conservation groups from their "misdirected" challenges to the use of DDT. Dr. Borlaug's concerns about the food production needs of an overpopulated world are valid but poorly expressed; but his talks, far from providing the insights one expects of a Nobel laureate, obfuscate the issues and distort the contributions of American conservation groups who have, for a quarter-century, attempted first to educate, and now to counter by court challenges an arrogant, environmentally myopic, and commercially-oriented coalition of the USDA and segments of the chemical industry.

J. Gordon Edwards is also a relative newcomer to the pesticides debate, and another who has never published so much as a scientific note on DDT or birds, both areas he now professes to analyze professionally. He is in many respects the most difficult of our critics to understand. He writes and lectures extensively and has had "a good press." On March 18, 1971 he testified[10] before the House Committee on Agriculture and his testimony was given wide circulation. A condensed version was distributed in pamphlet form by Terra Society, a new organization which purports "to serve the needs of man in his total environment through research and education on chemicals and their use to improve the physical and aesthetic standards of the world." Terra Society says it chose to distribute Dr. Edwards' broadside "because this man's testimony . . . analyzes the predominantly circulated arguments used to attack DDT."

The Edwards testimony, like all his attacks on those who would

ban DDT, is so wide-ranging, so replete with distorted references to scientific literature, and so sprinkled with unsupported opinion that it is difficult to comment on except on a line by line basis. Dr. Robert B. Finley, Jr., a respected investigator of wildlife-pesticides relationships at the Denver Wildlife Research Laboratory, U. S. Bureau of Sports Fisheries and Wildlife, was so incensed by the distortions Dr. Edwards introduced into the hearings that he wrote Chairman W. R. Poage a 14-page (single-spaced) critique on August 2, 1971. These corrections were unfortunately not published with the record of the hearings. Such Congressional hearings point up the futility of trying to present "both sides" of a controversy when the proponents of different points of view are allowed to operate on different levels of presentation. The advocates of *status quo* in the use of pesticides often decry recourse to the courts as "unscientific."[11] Court hearings, however, at least have the merit of presenting testimony under oath and subjecting witnesses to cross-examination.

Donald A. Spencer's most quoted input to the pesticide controversy is a twenty-page leaflet, *An Ecologist Views the Environment,* first distributed in large quantities in 1970 by NACA—to schools, agricultural experiment stations, U. S. Forest Service field offices, congressmen, etc. Although touted as "one of the country's outstanding authorities on wildlife biology" by his employer, NACA, Dr. Spencer spent most of his career as a small mammal control specialist, testing the effectiveness of various chemical poisons on mice. A thirty-title bibliography of his technical publications is almost entirely devoted to small mammal control, the one field in which he was an acknowledged expert. It should be noted that although scientific research on birds has provided the most telling evidence of environmental contamination by pesticides, Spencer's leaflet contains not a single citation to the extensive literature on bird-pesticide relations.

Perhaps the most telling rebuttal of Spencer's recent writings on behalf of the chemical pesticides industry is the fact that in June 1971 the Wildlife Society—the professional wildlife management association—was moved to publicly denounce Dr. Spencer, one of its own members, in these words: "A pamphlet by Donald A. Spencer entitled *An Ecologist Views the Environment,* published and distributed by the National Agricultural Chemicals Association, has caused serious concern among many members of The Wildlife Society.

"In the opinion of the Wildlife Society, it is a skillfully-prepared

document of a familiar kind, in which the facts are selectively chosen and assembled in a fashion that makes a particular case rather than putting the hazards of using persistent pesticides in accurate perspective.

"The Wildlife Society is convinced that the document gives false assurances of safety and security of wildlife populations, and that the most significant facts concerning the effects of persistent organochlorine insecticides on wildlife are omitted or discounted. The Society believes that selections, omissions, and irrelevant inclusions are typical procedures followed throughout the document.

"The Wildlife Society considers the pamphlet to be misleading and a disservice to conservation of wildlife and the environment. This statement is endorsed by the Council of the Society."[12]

Most interestingly, following a heated television debate in Detroit, Spencer insisted that he had not authored *An Ecologist Views the Environment,* but that this had been pieced together, presumably by a public relations firm, by lifting "out of context" items from his various written talks.

Historical Sketch

Before exposing more of the irrationalities involved in the diatribes of this quintet of DDT apologists, it will add perspective to outline the history of the 25-year pesticides controversy. It is an important chapter in the history of science and technology.

As the first of a long series of synthetic chemical insecticides introduced into general use by industry, with USDA approval after World War II, DDT is a classic example of technology outrunning the science supposed to protect us from the misapplications of technical know-how.

First used by the military in World War II, mostly in powder form, DDT undoubtedly saved millions of lives from typhus, malaria, and other insect-borne diseases, both during and after the war. Post-war uses, however, involved DDT in oil or other solvents —mostly to facilitate aerial application over large areas—and this made it lipid (fat)-soluble. Our troubles began here.

At first it was thought that the chief problem was merely one of determining optimum use—no more than one pound of DDT to the acre, or one-half pound over water, because it was soon observed that fish and other aquatic forms were particularly vulnerable. Compared to many other insecticides, DDT is not highly (acutely)

toxic, but this is unfortunately deceptive, since it is now known that its chronic toxicity is its most pernicious effect.

The first scientific clue to this delayed effect (chronic toxicity) came to light in 1958 when Dr. Roy Barker[13] of the University of Illinois discovered that DDT applied to elm tree foliage in the spring of one year could kill robins a whole year later. Several field studies[14] demonstrated that this particular use of DDT was very destructive of bird life. One can perhaps control excessive dosage, but there is no protection against low-level accumulations of DDT.

The biologist is not concerned about birds *per se,* since he knows that ordinary mortality in birds and other wildlife species is normally compensated for, but he sees birds as a sensitive indicator of environmental quality—a sort of litmus paper test. He is concerned about the welfare of life processes themselves when some population imbalance (birds, fish, or others) warns him that something is going wrong with our life-support systems—the plant-animal communities that keep the planet productive and livable.

The long-lived characteristic of DDT[15] (up to 50% of it may remain active in the environment a full ten years), and its fat-solubility, cause it to be cycled in nature's food webs, and to be magnified in the process. Although barely soluble in water (and thus neglected as "insignificant" for years), we now know that it is magnified hundreds or even thousands of times in being passed from one food level to another—and that it ends by killing or severely handicapping species at the ends of long food chains. Man himself is one of these "last guys" in the food chain system.

By 1960 we knew that DDT was causing serious damage to living systems out-of-doors, but we did not yet know the exact mechanisms of damage. In 1964, New York scientists[16] learned that as little as 3.0 parts per million (ppm) of DDT in lake trout eggs would kill the young fish fry at the egg-yolk absorption stage. Fish and birds became the test animals in a vast scientific detective hunt for the mechanisms of DDT poisoning. We knew that millions of robins were being killed in the northern U. S., that peregrine falcons had stopped nesting in the eastern U. S., that pelican populations had collapsed on the Gulf Coast of Louisiana and Texas, that bald eagle populations and fish-eating osprey populations were also collapsing in many parts of their range.

In 1967–68 a series of scientific discoveries began to provide

the missing links in our understanding of what was happening to wildlife. Following a scientific conference on the disappearance of the peregrine falcon in the eastern U. S. (held at the University of Wisconsin in 1965[17]) a British researcher, D. A. Ratcliffe[18] discovered that peregrine eggs laid after World War II had shells roughly 20% thinner than a similar sample laid prior to 1945, when DDT and similar pesticides (dieldrin, aldrin, endrin, heptachlor) came into use in agriculture, public health, etc. Dr. J. J. Hickey and co-workers[19] at the University of Wisconsin soon confirmed that the same thin-eggshell phenomenon exists in several U. S. bird populations (pelicans, eagles, peregrines, etc.).

At about the same time other researchers[20] working with rats as test animals discovered that dieldrin (and, later, DDT) causes the liver of exposed animals to manufacture an enzyme not normally present in these animal systems. This same enzyme induction was soon shown to be operative in several bird species, and scientists at the Patuxent Wildlife Research Center of the U. S. Fish & Wildlife Service then demonstrated[21] that the thin egg shells and the attendant lowering of reproductive success (50% to 75% mortality) so widely observed in nature were reproducible under scientifically controlled experimental conditions. DDT, its breakdown product DDE, and dieldrin, all interfere with body physiology in rats, several bird species, and man. We are not yet sure of the implications of enzyme induction by DDT in man except that it complicates the prescription of drugs, since doctors should now know DDT levels in their patients before prescribing such drugs as phenobarbitols.

Beginning in 1969, several scientific reports appeared which firmly implicated DDT as a causative agent in cancerous growths (carcinogenicity) in test animals. The evidence is similar in nature to that which caused the Food and Drug Administration (FDA) to ban the use of sodium cyclamate in American diets in October 1969. Thus on November 12, Secretary Finch of the Department of Health, Education and Welfare (HEW), asked the Departments of Agriculture and Interior to join him in "phasing out" the use of DDT within two years.

Just as the controversy over the health effects of smoking tobacco continues, almost wholly because of economic commitments, a full ban on DDT will continue to be resisted. But many feel that the evidence is in, and that positive action is now overdue at federal, state and local levels. Thus we applaud the June 14, 1972 decision

of William D. Ruckelshaus, Administrator of the EPA to cancel all but a few minor registrations of DDT, thus announcing a virtual ban on this chemical in the United States effective December 31, 1972.

The National Audubon Society was the first national conservation organization to warn in 1946 of the environmental hazards involved in the "massive" use of DDT, i.e., in aerial applications covering widespread areas.[22] For two decades thereafter, Audubon officials attempted again and again to enlist the cooperation of the USDA in limiting the uses of DDT and related pesticides, always with minimal results, and often at the price of being derided as alarmists.

The first concerted opposition to USDA pesticides programs developed in 1959 when all the major conservation organizations joined in opposing the fire ant eradication program in the southeastern U. S. This program still continues at a "control" level, but opposition at least forced the USDA to "discover" that half a pound of heptachlor to the acre would control ants as well as the two pounds originally prescribed by its experts. When, after years of advocacy, it was discovered that heptachlor degrades to an even more toxic epoxide when released in the environment, the less toxic but still environmentally objectionable chemical Mirex was substituted. A major court challenge against the USDA's gypsy moth eradication program was launched by ornithologist Robert Cushman Murphy in 1957, and was finally defeated in the U. S. Supreme Court in 1959; but this suit at least caused the USDA to reconsider and largely abandon its eradication approaches for well-established pests.

Little else changed until Rachel Carson's SILENT SPRING (1962) was read by more than a half-million people, including President John F. Kennedy. This led to the formation of a host of pesticide review or pesticide control boards and committees at state and federal levels, and the production of two President's Science Advisory Committee (PSAC) reports.[23] Although the 1963 PSAC report agreed that most of Rachel Carson's concerns were valid, and although the committee made several forceful recommendations, few were acted upon, and none with enthusiasm until—having exhausted administrative remedies—the conservation groups took their case to court and exposed the arbitrary and inadequate pesticides registration process of USDA. The National Academy of Sciences—National Research Council[24] tried twice to grapple with

the pesticides problem, but failed each time, largely because it was dominated by chemists.[25]

In 1967 the National Audubon Society underwrote the costs of making a transcript of a new DDT court challenge, a new series of class actions, in the hope that this would further expose the issues to public scrutiny and overcome entrenched bureaucratic conservatism. The plaintiffs were a small group of Long Island, N. Y., residents who shortly thereafter formed the Environmental Defense Fund, Inc. (EDF), one of the first, and most energetic of a new kind of public interest firm. The National Audubon Society later subsidized EDF through court challenges in Michigan, and through the decisive DDT hearings in Wisconsin, the first state to ban DDT because it was adjudged an environmental contaminant.

In 1969 EDF, National Audubon Society, Sierra Club, and the West Michigan Environmental Action Council petitioned the Secretary of Agriculture to bar the use of DDT by "suspending" and "cancelling" its registration as a pesticide. The hearing process took nearly three years because our laws have traditionally favored the producer over the consumer. Unfortunately, also, the existing laws relating to chemical pesticides registration were drafted long before there was scientific awareness of the environmental hazards that some of these chemical poisons pose. The law focuses on the prevention of "imminent hazards to human life," but DDT has low toxicity for large mammals like man, whose slower metabolism (compared to birds, etc.) and detoxifying mechanisms afford some protection. Thus most of the defense of DDT has hinged on this technical point embedded in law, and most agriculturists, food producers, and their chemical suppliers have refused to enlarge their awareness to include responsibility for the environmental contamination which seriously affects many lower forms of life. They have disregarded the significant distinction between the acute and chronic or cumulative effects of their chemical tools.

Indeed, we know now that DDT, like the related PCBs (polychlorinated biphenyls used industrially), contaminates the entire biosphere at low levels, but that these minute quantities of long-lived [toxic] chemicals enter food webs and are magnified in the process of being passed from one link in the food chain to another. It has been argued, on what were thought to be conservative scientific grounds, that "research showing the effects of pesticides on fish and wildlife in the Chesapeake Bay cannot be applied to fish and wildlife generally." As I have pointed out elsewhere,[26] however,

"If this is a scientific imperative the agribusiness community should be asked to apply chemicals only after a farm-by-farm study of externalities. It is true that the maximization of net returns in pesticide use of cotton requires different resource allocations in Alabama than in California, but this is so precisely because maximization is sought despite differing profit margins. On the other hand, long-lived, fat-soluble hydrocarbon insecticides tend to be magnified in food webs in both Alabama and California because the natural mechanisms responsible for this magnification of barely perceptible quantities (DDT in water, for example) to acutely toxic levels after four or five transfers through trophic levels are functionally similar (though they involve different species). The end result of this process is the maximization of biological insult, resulting in death, and is objectionable whether it happens to Connecticut's ospreys or California's western grebes, both species at the ends of contaminated food chains."

Weak Apologia

Much has already been said about the irrationalities of most DDT apologia, but it may help to dissect some of the typically extreme claims made by the several defenders of DDT under review.

Leaving aside the merely emotional criticisms, what factual questions posed by the anti-anti-DDT forces deserve attention? This must unfortunately be done in general terms because research scientists refuse to become involved with criticisms "that do not deserve scientific discussion"—criticisms that other scientists are, or should be, competent to see through for themselves. Since, however, our anti-anti-pesticides critics are scientists competent in one area who have taken it upon themselves to speak in areas quite outside their competence, someone needs to redress the balance.

Jukes wrote, "If the manufacture and export of DDT are banned in the United States, the world-wide antimalarial program will collapse [because] a ban in the United States would lead to prejudice against the use of DDT elsewhere."[27] This is partly true, but only in the sense that if the U. S. decided that DDT was not good enough for itself, this might alert the rest of the world to problems they are now insensitive to. This is why the National Audubon Society initially suggested that what was not good enough for domestic consumption should not be exported. When the World Health Organization (WHO) insisted it needed DDT for

world malaria control, however, we did not press the issue, though we are currently researching the adequacy of WHO's pesticides screening program to try to establish how dependent the world is on this one chemical.

Almost all apologists for DDT have insisted[28] that environmental levels of DDT in world environments, whether in Antarctica or elsewhere, were infinitesimal and would not even be detectable except for new laboratory equipment of hypersensitive accuracy. It is perhaps true that we can detect single molecules of a foreign substance with modern equipment, but our responsibility is to ask what the effect of these molecules may be. Undetected, we might simply have an observable effect that could not be explained. What sensitive analytical devices like vapor phase chromatography and electron capture have allowed us to do is to trace back physiological effects to their source, even when a very few parts per billion in the environment may be the causal mechanism. However, "the claimed detection of DDT in Antarctic penguins at levels in the range of one part per billion"[29] actually involves contamination as high as 180 parts per billion.[30] The "magic bullet" quality of DDT[31] is an advantage only for those who disregard the development of insect resistance against this chemical and discount the other organisms who may be or indeed are affected by this same chemical.

Jukes says of the malaria control program: "I have not mentioned cost, because this should not be a prime consideration when many human lives are at stake."[32] But we know that alternative, environmentally acceptable mosquito control chemicals are available, and that WHO does not use them because it considers them uneconomic for its particular task. Our continuing use of DDT is therefore in part an insistence on making the least dollar investment in these programs; with more willingness to share its largesse, the United States could subsidize a less environmentally destructive malaria control program and accomplish the double objective of controlling malaria and controlling environmental pollution.

Agriculture

Jukes says that "Obviously a group of crop plants such as potatoes, corn, tomatoes and alfalfa, cannot be grown as a mixture."[33] This is an unthinking defense of agricultural monocultures that Cornell entomologist David Pimental[34] has shown to be false,

even though he did not test the particular random combinations proposed by Jukes. Indeed, modern, intensive, technological agriculture is the happenstance result of emphasizing one factor—monetary return for the individual producer—while neglecting most others. This is what caused anthropologist Margaret Mead[35] to complain, properly, that agriculturists have become more interested in producing commodities—whatever their ultimate use—rather than producing food for people. This is also why, at least in part, we continue to have malnutrition and near-starvation in the midst of plenty.

As already suggested, Borlaug, Jukes, and White-Stevens are also victims of the myopia which affects most promoters of agriculture. A common, popular fallacy foisted on the general public by these apologists is the notion that any restriction of pesticides is tantamount to the elimination of all agricultural chemicals—pesticides and fertilizers—and threatens a return to the dark ages of civilization. Borlaug wrote, "During the long, obscure, dimly defined prehistoric period when man lived as a wandering hunter and food gatherer, chronic food shortages must have forced man to expend virtually all of his energies in struggling to feed himself, and thereby precluded him from developing a sedentary way of life."[36] How, then did man break out of these chains? The fact is, as Richard Lee and Irven DeVore[37] have shown, that primitive man's life, far from always being "nasty, brutish, and short," was economically superior to modern man's existence in the sense that the necessities of life which hunting and food gathering yield were provided in less than four days of every week, rather than the five or six that has characterized industrial man's lot. This, we may suggest, is what allowed primitive man to dream and invent a variety of civilizations on every continent he occupied.

A related fallacy is the widely publicized "fact" that modern agriculture involves only 5% of a nation's population in food production. This is so only if one erroneously accepts the notion that today's farmer is a self-sufficient producer, as he came near to being a few generations ago. Today's farmer is completely dependent on industry to provide him with the sophisticated machinery he uses, the gasoline he buys to power this machinery, the fertilizers he buys instead of produces, the pesticides he buys to try to protect the festive board his monocultures spread for various pests, and the bank loans he must have to make the heavy seasonal

investments his intensive practices require. It still takes 20% to 25% of our total population to grow the food fibers that 40% of us produced 80 years ago, and that 80% of us produced during prior centuries of the agricultural revolution. The notion, expounded by Borlaug, that governments must assume a fair return on agricultural investment lest farmers be driven off their farms "and into the slums of the large cities" is particularly ironic. It is "progress" in the technology of agriculture, with government subsidies, that has so driven down prices (by multiplying productivity and investment) that marginal operators have been squeezed out of business. Our vaunted American agricultural progress was won by displacing millions of people who have been forced to congest the cities and contribute to their present decline. The "green revolution" Borlaug has helped launch, although it does promise more food, may, unless a variety of social institutions[38] are modified in time to accommodate it, end by contributing to similar socio-political and economic dislocations.

Wildlife

As already suggested, none of our critics—except Spencer, who has misused his talents in this area—are competent to discuss the effects of pesticides contamination on wildlife populations. This fact was made explicit on September 22, 1971 when Jukes was denied standing as an expert at the EPA hearings on DDT, since it was shown that he had done no original research on DDT or wildlife.

The fallacy of longest standing is White-Stevens' insistence that Audubon Christmas Count data show an increase in robin populations. What this chemist-turned-ornithologist failed to notice, or refused to accept, is that there are more participants now, and that growing competition among participants has caused them to work harder and otherwise to perfect their skills at finding, identifying and counting birds. From year to year, therefore, the improvement has rendered the counts unreliable for comparisons of total numbers reported, though they have become better clues to the occurrence and distribution of species.

The robin is among the most widely dispersed summer resident birds of the continent, and therefore among the numerically most abundant species we have. It nests in every state and every province of the U. S. and Canada, with nesting densities increasing as one moves northward from the southern tier of states. We do not know,

however, where its greatest wintering densities are, though we know that some unmeasured fraction of the total population winters in Mexico. The Audubon Christmas Counts would be helpful in mapping the areas of highest winter densities in the U. S., but no one has as yet done this. We do know, however, that the highest density of Audubon Christmas Counts, being in the northeastern U. S., does not correspond to the area of highest distribution of winter robins, since these birds are then mostly farther south. Aside from these problems, it is likely that our count circles assess too small a sample of the winter habitats of the robin to be a reliable index to the total population.

To complicate matters, winter robins tend to flock together in sizeable roosts, and these roosts may shift from one place to another in succeeding winters. One winter the roost will be inside the 15-mile diameter area of an Audubon Christmas Count, another winter outside. The numbers of robins *reported* may thus fluctuate considerably on the basis of this mere happenstance, not on the basis of changes in their total numbers. The robin counts recorded at Nashville, Tennessee (Fig. 1) illustrates this

FIGURE 1

Robins recorded in Nashville, Tenn., Audubon Christmas Count (from *American Birds* and its precursor, *Audubon Field Notes*).

1952 (53rd Count)	1100 robins
1953	4000
1954	541
1955	143
1956	3600
1957	355
1958	5000
1959	37
1960	800,000
1961	11
1962	500,000
1963	162
1964	1500
1965	91
1966	33
1967	9562
1968	32
1969	3100
1970	7
1971	500,000

well, and shows why the crude summations of Audubon Christmas Count data used by White-Stevens, Jukes, Marvin, and others to justify their claims that birds have increased in number are invalid.

No ornithologist has ever used these data to claim bird species increases, nor has the National Audubon Society ever used them to back a claim that one species or another had declined in numbers. We know better.

The bald eagle, our national bird, is one of those species at the end of a long food chain (it is a fish-eater) that has suffered seriously from DDT pollution. The National Audubon Society has been involved in a nine-year cooperative research and conservation project with the Bureau of Sport Fisheries and Wildlife, Forest Service, National Park Service, and scores of other agency, university, and private field biologists, and is now preparing various aspects of this field and laboratory material for publication. The most significant result of this work is the demonstration of a direct relationship between DDT (and DDE) body burdens and reproductive success. The higher the burden, the less success, largely because thin eggshells prevent successful incubation. This, as one would expect, is a regional phenomenon, so that those eagles lucky enough to nest and winter in less contaminated environments continue to produce some young.

The osprey is a large fish-eating hawk, and as such is an ecological parallel to the bald eagle in food habits. It has suffered equally from DDT poisoning, exhibiting the same thin eggshell syndrome, etc. One of the most impressive documentations of the relationship between high DDT burdens and low reproductive success is illustrated by the relation between Chesapeake Bay and Connecticut osprey populations. Chesapeake Bay has lower DDT levels and its ospreys reproduce much better than those of Connecticut, where DDT contamination is high. When the eggs of Chesapeake Bay birds are transplanted to Connecticut nests, they hatch at the same rate as they would have if left in their own nests, whereas Connecticut eggs fail at the same rate in Chesapeake Bay nests as they would have if left in their own nests. The failure to hatch and produce viable young is thus a result either of DDT burdens or genetic defect. But we know from a long series of experiments that DDT burdens are a sufficient cause of failure, and there are no other apparent malfunctions in Connecticut osprey populations. We also know that dieldrin is itself a sufficient cause of hatching

failure when present in eggs in sufficient amounts, but the thin eggshell syndrome's relation to DDE is already fully demonstrated scientifically, and is not dependent on dieldrin, mercury, PCBs or other contaminants, despite frequent smoke-screen tactics to the contrary by DDT's apologists.

Although at least a dozen American bird species are now known to suffer from the thin eggshell syndrome, it will suffice to treat only two more, the peregrine falcon and the brown pelican, which have been subjected to reanalysis by Jukes and Edwards. Like Spencer, Jukes and Edwards have succeeded in obfuscating the issues by recourse to "skillfully-prepared document(s) of a familiar kind." They cite authorities, or their works, but fail to tell their readers that the conclusions they present are diametrically opposed to the conclusions reached by the scientists who did the research.

Jukes, for example, refers to the authority on peregrine falcon populations, Dr. J. J. Hickey, but discounts Hickey's conclusions that the peregrine decline is an extraordinary biological event, and not due to the usual human pressures that have caused a gradual decline in most American wildlife populations since white men began taking over the continent for themselves. Jukes seems to accept[39] the documented fact that the peregrine is no longer breeding in the eastern United States, but then introduces evidence alleged to counter this claim: "However, the counts of migrant peregrines at Hawk Mountain, Pennsylvania, were as follows. . ." The reader must be alert enough to recognize that a bird may no longer breed in the eastern United States, and yet may migrate past Hawk Mountain in those same eastern United States, since the migrants originate in northern Canada. Hawk Mountain data are therefore no clue to the status of eastern U. S. peregrines. Nor is the fact that they have always been rare compared to other species of any significance in evaluating whether or not they are now being affected by DDT. Jukes also conveniently ignores the implications of the fact that the Madison, Wisconsin peregrine conference organized by and reported upon by Dr. Hickey[40] was a search for hypotheses to account for the catastrophic collapse of the peregrine population of the eastern United States. The editorial task turned out to be a monumental one, had to be done as an extracurricular chore by Professor Hickey, and therefore the book appeared three years after the conference was held. This allowed the editor to update our understanding of the decline of the peregrine in a summary essay. But it is noteworthy that Jukes

quotes the preliminary views of the conference participants (Herbert and Fyfe), but not the man who had meanwhile done so much thinking about the implications of the original data. Instead he quotes a 1942 paper of Hickey's and leaves out more recent work by Cade[41] that shows that Canadian peregrine populations, too, are in trouble.

Instead of merely putting his own amateur interpretation on the works of experts in fields other than his own, J. Gordon Edwards actually attacks the methodology, the conclusions, and even the motives of these experts. Edwards devoted seven tight-packed pages of his Congressional testimony to the brown pelican, accusing biologists of the California Fish & Game Department and the U.S. Bureau of Sports Fisheries and Wildlife of "scientific persecution" of brown pelicans using or trying to use Anacapa Island off the California Coast as a nesting site. He ends a five-page typescript entitled *The Truth about the California Brown Pelicans* (late 1971) with an anguished "When will the public and the press become aware of the untruthful nature of the environmentalists' propaganda?"

It may be true that the status of the west coast's brown pelicans has not been clarified by a series of partial observations reported upon by various writers. A suspicious critic can therefore have a field day juxtaposing seeming contradictions if he overlooks or disregards that these seeming contradictions are probably results of different observational opportunities, oversight, or simply different objectives in observation. This is exactly why the California Department of Fish and Game and the U.S. Bureau of Sports Fisheries and Wildlife, intent on learning what factors affect these birds, have both instituted long-term studies. The principal students, Franklin Gress for the state agency and Daniel W. Anderson for the federal bureau, were both selected because they had already demonstrated competence in this area. Edwards' disingenuous criticisms have fortunately not caused responsible agency officials to change their minds about the competence of these field men.

Meanwhile, though he would have preferred publishing when his field study was complete, Edwards' political treatment of the issue of DDT's effects on pelicans led Dr. Anderson to publish a November 30, 1971 interim report, *The 1971 Status of California Brown Pelicans*. This report, which will be accepted as indicative by most of the scientific community until a more detailed summary of data is submitted for formal criticism, says that "Con-

tinued sampling for pesticide residues in Gulf of California browns (pelicans) substantiated past studies by these and other researchers in showing an inverse relationship between thin-shelled eggs and egg-index-residues of p,p'-DDE. Thin-shelled eggs and resultant breakages were a major cause of nest abandonments and reduced clutch sizes in 1970 and to a lesser degree in 1971."

Jukes wrote "As a means of arousing alarm concerning DDT, the EDF and the National Audubon Society have both stated that DDT causes cancer. The implication that DDT in breast milk may cause cancer in babies is superlatively sensational copy."[42] It is not true that the National Audubon Society has told people that DDT causes cancer in man. We have raised the question, however, because it is a question many experts are properly concerned about. All rational students of this problem agree that there is no *proof* that DDT causes cancer in man; that such causation, if it does occur, is at low levels; and that, conversely, there is no *proof* that DDT does *not* cause cancer in man. The failure to find evidence is much too often taken to indicate that there is none to be found. Many apologists for DDT are guilty of obfuscating this issue. A recent summary statement of this complex problem was made by cancer specialist Dr. Samuel Epstein, who stated at EPA's DDT hearings that "DDT has been shown to be carcinogenic (to mice) in a series of well-designed experiments on the basis of standard toxicological carcinogenesis procedure and philosophy. We have no reason to exclude the fact that DDT represents a significant carcinogenic hazard to man."

The Human Dilemma

The 25-year pesticide controversy is clear evidence of a serious failure of our social institutions to guide the application of modern technology. The attitude of many chemical company officials during this controversy has demonstrated the more vicious side of the private capitalism that dominates our economy. The destructive side effects of the use of many of our present armory of chemical pesticides were little known, and little questioned, when this technological response to insect pest problems was instituted. Some chemical pesticides have, of course, been in use for a long time, but the synthetic chemical technology discussed here dates from World War II only. Given the heavy policy and fiscal investments in this pest control approach, the first response to the

challenge involved in wildlife mortality—especially since this was at first brought to light by "birdwatchers"—was to deny the problem and to make countercharges of emotionalism. Except for the handful of incompetent or dishonest defenses of DDT outlined in this article, however, the principal roadblock to eliminating the contamination of DDT use is now two-fold: first, a narrow positivism exists which focuses on imminent hazards to man and discounts wildlife losses as minor or irrelevant; and second, we tend to believe ourselves so dependent on DDT in agriculture and public health that wildlife losses are labeled a necessary price for the production and protection we value more.

All present chemical approaches to insect pest control are doomed to failure because insect populations are versatile enough to develop resistance through evolutionary adaptation to the new chemical parameters we impose on their environments. DDT has already become ineffective against more than 200 insect species. Its use in the United States, mostly in cotton growing, was obviously self-limiting even before EPA's 1972 ban. Tragically, the obdurate insistence on using it to the bitter end of its effectiveness—mostly for private pecuniary advantage and in disregard of the social costs it imposes—has poisoned the world and impoverished the world's fauna. This has happened at the very time when western man, having solved most production problems, is again turning to the enjoyment of Nature's diversified biota to help balance his increasingly boring artificial existence. Having escaped the struggle for existence involved in material scarcity, he is rediscovering that he is still part of Nature, and that he is a part of Nature aware of himself, and thus trustee for all continuing evolution.

The proximate problems of the technologically less advanced Third World—like those of ghetto blacks, American Indians, Mexicans, and Puerto Ricans in the United States—are of course very different. Their's is still the task of filling the belly. This is perhaps a problem of overconsumption by the "haves," and underconsumption by the "have nots;" it is certainly the dilemma of world overpopulation based on low natural resources carrying capacity and poor social organization.

Ironically, and most tragically, it turns out that the new dependence of the Third World on DDT now poses a cruel dilemma which has been completely ignored by the DDT apologists. The World Health Organization has announced[43] that unless DDT

use in world agriculture is soon phased out, malaria control programs will become increasingly ineffective because the malaria vectors—mostly Anopheline mosquitoes—are developing resistance to DDT faster than WHO's public health programs can break the fatal links between human malaria reservoirs and new human victims. WHO claims that DDT allowed it to remove or greatly reduce the threat of malaria for a billion people in the last 25 years. But since the resulting population growth spurt imposes new food production requirements, DDT—because it was cheaper than other pesticides and at first effective against a broader range of insect pests—was pressed into extensive use in agriculture.

Unfortunately, food production has not caught up with population growth, though decade after decade the professional optimists have promised that success was just around the corner. After nearly thirty years of this struggle, the WHO and FAO together have brought the number of people at the verge of starvation to 1.3 billion. The WHO malaria control programs are now jeopardized, not, as our critics claim, because environmentalists insist DDT should be banned in the U. S., but rather because DDT continues to be used in Third World agriculture. This has happened because two groups of experts have failed to coordinate their programs so as to avoid conflict, and each now claims to be dependent on the continuing use of a pesticide whose effectiveness is destroyed by its own use.

FOOTNOTES

* Staff Biologist and Vice President, National Audubon Society, New York.

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[25] Chemists are today's most narrowly positivistic scientists, and as such have had difficulty accepting the much more dynamic view of the reality of ecosystem contamination presented by ecologists and other outdoor-oriented scientists. I use the word positivistic not in terms of scientific reductionism, which is a necessary methodology, but to describe that unphilosophic attitude which causes so much learning to deteriorate to a conservative absolutism on one hand, or to a cynical relativism on the other. It was this positivist's option A. N. Whitehead warned about, as paraphrased by Ralph V. Norman, Jr.: "The positivist, too modest to go searching for connections that have not appeared, simply states what he sees and only what he sees. But there is arrogance in such modesty; its rigid assumption is that we know already what system is. What our systems cannot organize, nothing can organize." Norman, R. V. Jr., *Whitehead and Mathematicism,* in Kline, G. L., ed., ALFRED NORTH WHITEHEAD: ESSAYS ON HIS PHILOSOPHY (Prentice-Hall, 1963). Yale biologist Edward S. Deevey once pointed out that "The naive and mischievous notion that biology is reducible to chemistry is held by many chemists, a few biologists, and an inordinate number of college deans." All positivists have overlooked the hierarchical organization of reality, and we are victimized by a lingering typological outlook, an inheritance of two thousand years of "special creation" assumptions not yet destroyed by Darwin's vision of a continuing organic evolution. G. G. Simpson showed that the physical sciences deal in "types of things" (atoms, molecules) and are thus typological; but that when life enters, every organism and every population (every ecosystem) has a history that continually modifies it and makes it unique. The exact replication of experimental reactions which the chemist considers his test of truth becomes only generally recognizable as trend or experience where unique things, rather than types of things, are involved. Simpson, G. G., *Biology and the Public Good,* AMERICAN SCIENTIST, 55:2 (June 1967).

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